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Original Article

Major and trace elements in different types of Egyptian mono-floral and non-floral bee honeys

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Abstract

The chemical composition of bee honey varies with the surrounding environment (major floral and soil contamination), which reflects the nutrition value of honey. Trace elements Co, Cu, F, Fe, I, Mn, Ni, Sr and Zn and major elements Cl, Na, K and Mg as well as toxic elements Cd and Pb were all determined in different types of bee honey which include non-floral honey with artificial feeding (syrup -feed honey), and mono-floral honeys (sesame honey, orange honey and clover honey). These elements were also determined in the bee feeds, which include flowers (sesame, orange and clover) and syrup. The results revealed that of all types of honeys, syrup-feed honey exhibited higher concentrations of Cd, Cl, Co, Fe, K, Mg Mn, Na and Pb than in the other honeys. Orange honey contained the lowest element concentrations. Clover honey had the lowest toxic element Cd and Pb concentrations (0.01 and 4.2 μg/g, respectively) while sesame honey contained the highest levels of Cd and F (0.5 and 12.5 μg/g), respectively. Statistical analysis revealed significant correlation between honey and the feed (R, 0.770–0.971). Cluster analysis of the honeys data revealed that the origin of the honey samples correlated with its chemical composition. Element concentrations in the honey under study were in the safety baseline levels for human consumption.

Keywords: Bees honey; Trace elements; Toxic metals; Environment; Brown honey

1. Introduction

Honey is a very important energy food and is used as an ingredient in virtually hundred of manufactured foods, mainly in cereal based products, for sweetness, color, flavor, caramelization and viscosity (LaGrange and Sanders, 1988).

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The composition of honey varies with the feeding of the bees; it may be naturally from nectar of plant utilized by bees or artificially by feeding bees with artificial sources such as sugar or syrup (syrup is a brown molasses produced from sugar industry and known in Egypt as Brown honey). Contents of Na, K, Ca, Mg, Cu, Fe, Mn and total ash were determined in 21 samples of Spanish commercial honeys (Rodrigues-Otero and Paseiro, 1992). Ca, Mg, K, Na, Fe, Cu, Cr and Pb in different samples of commercial Spanish eucalyptus honeys were studied, in which K, Na, Ca and Mg were present in large quantities (Bonvehi, 1989). Instrumental neutron activation analysis was used for the determination of As, Cr, Sb, K, Br, Zn, Fe and Co in five varieties of Turkish honey; the highest levels were detected in Bolu Yak, mixed flower honey (Sevimli and Bayulgem, 1992). Na, K, Mg, Cu, Fe, Mn, P, Cl, Si and S contents of 91 samples of raw honey from Galicia (northwest Spain) were determined and had high mineral contents in comparison with other honey reported in the literature (Rodrigues-Otero and Paseiro, 1994). Eighteen samples of monofloral honeys from Murcia region (Spain) were studied for minerals content; the samples were low in mineral content (Bries et al., 1993).

Lead as toxic metal was assessed in some types of honey in Malaysian (Shahid and Sion, 1987). Mercury levels in bee honey samples from industrially contaminated and non-contaminated areas were determined (Toporacak et al., 1992). Honey mesquite (*Prosopis juliflora*), a representative species of the Sonoran Desert (USA) ecosystem, was studied as a possible bioindicator for industrial smelter pollution. Zn, Cu, Fe, Ti, Mn, Al, Mg, Cs, Sm, Ce, U, Th, Yb, As, La, Hf, Sb, V, In, W, Ba, Br, K, Na, Cl and Au were all determined in honey from Arizona area the identification and specification of smelter emissions in honey mesquite make the honey a bioindicator for smelter pollution (Gabriel, 1999). In addition, honey is a good indicator for the chemical constituents of the plants and their monitoring. Many researchers (White et al., 1962; El-Sherbiny and Rizk, 1979; Mesallam and El-Shaarawy, 1987; Sanford, 1994; Iskander, 1995, 1996; Kump et al., 1996; Yilmaz, 1999) have published studies on trace elements in honey.

Bee honey can be a good source of major and trace elements needed by humans. Their presence in human food is very important, but if they exceed safety levels, they can be toxic (Codex Alimentarius, 1993; Valkovic, 1975).

This study aimed to monitor major and trace elements in different types of bee honeys from different feed sources (natural and artificial feed) as well as in flower and syrup utilized by bees and collected from the Nile Wadi in South Egypt. In addition, the study applied cluster analysis to determine the origin of honey samples.

2. Materials and methods

2.1. Samples collection

Ten samples (1 kg each) of each monofloral honey (sesame honey, clover honey and orange honey) and the flowers of sesame, clover and orange (50 flowers of each) were collected from the farms and bee colonies. Another ten samples (1 kg of each) of syrup-feed honey and syrup were collected from other bee colonies that used syrup as a feed. These bee colonies were located at two different environmental sites along Nile Wadi in South Egypt; 3 colonies of monofloral honey from the agricultural area at Esna city (150 km north of Aswan) and the other of syrup-feed honey from the industrial area at Naja Hamady (350 km north of Aswan). Honey and syrup samples were collected in glass bottles and stored in the dark at 3–4°C until analysis.

2.2. Sample preparation and measurements (for atomic absorption spectroscopic measurement)

Flower samples. Flowers were washed with tap water followed by bidistilled water and oven dried at 105°C for 24 h. The dried sample was crushed and powdered to 100 μm, one gram of each powdered sample was digested using 20 mL $HNO_3/HClO_4$ (3:1) acid mixture, then heated to a clear solution for three hours, and continued near dryness. The cooled residue was dissolved in 5 mL 2 N HCl and made up to 50 mL using bidistilled water (AOAC, 1984).

Honey and syrup samples. Sample was oven dried at 105°C for 24 h. One gram of the dried sample was digested using 20 mL $HNO_3/HClO_4$ (1:1) acid mixture then heated to a clear solution for 3 h and continued near dryness. The content after cooling was extracted using 1 N HCl and completed to 50 mL by bidistilled water.

2.3. Contamination control and analysis

Accurate multi-element analysis at trace levels (ppm and ppb) is dependent upon the prevention of element contamination. All stages of sample preparation and analysis were carried out in a clean air from the studied elements. All laboratory equipment used for analysis was made of Pyrex, washed with HNO_3, rinsed twice with bidistilled water and placed in a clean environment until dry. All reagents used were of analytical grade (BDH, Merk). Certified standard solutions 1000 ppm (purchased from BDH Ltd., UK) of elements Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr and Zn were used for flame atomic absorption spectrophotometer (AAS).

Element concentrations of Cd, Co, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr and Zn were measured using flame atomic absorption spectrophotometer, PYE UNICAM SP 1900. Hollow cathode lamps of the studied elements were used at the recommended conditions cited by the manufacturer; PYE UNICAM SP 1900.

2.4. For ion selective electrode measurements (ISE)

Apparatus. Orion 940 EA microprocessor ion analyzer with direct read out concentration, Orion chloride (cat.no.94-17), fluoride (cat.no.94-09) and iodide (cat. no 94-53) electrodes, single and double junction reference electrodes were used. Working standard solutions of Cl, F and I were prepared from standard solutions (1000 ppm of each Cl, F or I purchased from BDH company, UK).

Fluoride (*flower sample*). One gram of the finely ground sample was fused with sodium hydroxide at 600°C in a muffle furnace for 30 min in a covered nickel crucible. After cooling, the residue was dissolved in deionized water and the pH was adjusted to 8–9 with 1 N HCl. After filtration, the filtrate was diluted to 100 mL by deionized water (McQuaker and Gurney, 1977).

Honey and syrup samples. 0.5 g of each dry sample was extracted with 1 M $HClO_4$, the pH was adjusted to 5.2 using 1 M sodium acetate, and completed to 25 mL with deionized water.

The resulted solutions of flower, honey and syrup samples were measured for fluoride using Ion Analyzer, Orion 940, fluoride electrode, Orion, cat. no 94-09 and single junction reference electrode, Orion cat. no 90-01. TISAB (II) was used as ISA (ion-selective adjuster).

Chloride (*flower sample*). The oven-dried sample (0.5 g) was extracted with 1 M $NaNO_3$. The mixture was stirred for 10 min and then filtered. The filtrate solution was brought to 50 mL (Orion Res. Inc., 1985).

Honey and syrup samples. The oven-dried sample (0.5 g) was extracted with 1 M HNO_3. The mixture was stirred for 10 min and then filtered. The filtrate solution was brought to 50 mL (Lacroix et al., 1970). To each sample solution of flower, syrup and honey, 1 mL chloride ISA (5 M $NaNO_3$) was added. Chloride was measured using chloride electrode, Orion, cat. no 94-17B and double junction reference electrode, Orion cat. no 90-02.

Iodide (*flower, honey and syrup samples*). One gram of the finally ground sample was added to 50 mL bidistilled water at 90°C and the solution was stirred for 30 min. After cooling, the solution was buffered to pH 6.8 using 0.35 M disodium phosphate and 0.38 M potassium dihydrogen phosphate. One mL of ISA adjuster (1 M $NaNO_3$) was added to the filtrate. Iodide was measured in the solution using iodide electrode, Orion cat. no 94-53 and single junction reference electrode, Orion cat. no 90-01 (Lacroix et al., 1970; Hoover et al., 1970).

2.5. Accuracy testing and statistical analysis

The precision (expressed as standard deviation SD and coefficient of variance CV) of the results was determined from six replicates of homogenized samples, giving a good standard and precision for the analytical results of trace elements obtained by AAS and ion-selective electrode analysis. The accuracy of the AAS and ISE methods was verified using the recovery test, which ranged from 93% to 103% for the studied elements.

Data were statistically analyzed for correlation analysis, regression analysis, and cluster analysis using MINITAB Release 13 program, US registered trademark of Minitab Inc.

3. Results and discussion

The results of chemical analyses of the studied honey, flower and syrup are cited in Tables 1 and 2.

The results showed that Cl, K, Na and Mg (and Fe in syrup-feed honey) were the most abundant of the elements in all types of the studied honeys with average concentrations of Cl, 722–36,800 μg/g dry weight DW; K, 215–15,550 μg/g DW; Mg, 102–1325 μg/g DW and Na, 378–2550 μg/g DW. The other elements Co, Cu, F, Mn Ni Sr Fe Cd Pb Zn and I were presented in low concentrations as trace elements (Table 1).

Some researchers reported K as the most abundant element in honey produced in Galicia (northwest Spain) with an average content of 1572 mg/kg, while the mean contents (mg/kg) of the other elements were Na 138, Ca 102, Mg 106, Cu 1.11, Fe 5.12, Mn 402, P 110, Cl 245, Si 9.16 and S 6.85 (Rodrigues-Otero and Paseiro, 1994). These element concentrations were lower than in the honeys we studied except for K and Mn. Another study reveals the presence of K, Na, Ca and Mg in larger quantities in eucalyptus honey produced in Spain than Fe, Cu, Cr and Pb

Table 1
Major and trace element concentrations (μg/g DW) in different types of bee honey

Honey type		Major elements					Trace elements									
		Cl	K	Mg	Mn	Na	Cd	Co	Cu	F	Fe	I	Ni	Pb	Sr	Zn
Sesame honey	M	1030	1500	102	1.70	378	0.50	1.75	1.70	12.5	202	0.74	1.25	6.3	0.50	7.20
	SD	36	350	2	0.25	20	0.00	0.35	0.35	0.90	22	0.35	0.35	1	0.0	0.38
Orange honey	M	722	528	225	0.50	412	0.01	1.75	1.0	4.8	80	0.87	1.7	5.7	0.50	5.0
	SD	40	38	9	1.0	80	0.10	0.35	0.0	1.8	17	0.10	0.25	0.25	0.1	1.0
Clover honey	M	11800	213	300	0.50	478	0.01	2.5	1.75	12.4	58	0.62	4.1	4.2	3.2	9.3
	SD	110	17	51	1	30	0.10	0.70	0.35	2.0	4.0	0.3	0.36	0.35	0.26	0.50
Syrup-feed honey	M	36800	15550	1325	5.7	2550	0.50	3.2	1.0	5.2	3690	0.69	3.0	9.3	0.50	7.0
	SD	300	261	66	0.35	229	0.00	0.40	0.0	1.0	79	0.12	0.0	1.0	1.0	1.0

DW, dry weight.
M, mean of ten samples of honey (μg/g).
SD, standard deviation.

Table 2
Major and trace element concentrations (μg/g DW) in the flowers and syrup feeds

Honey feed		Major elements					Trace elements									
		Cl	K	Mg	Mn	Na	Cd	Co	Cu	F	Fe	I	Ni	Pb	Sr	Zn
Sesame flower	M	10200	3520	7849	113	1.5	3062	9.5	25.7	5.0	4660	3.85	18.5	15.5	27.5	42
	SD	80	70	50	4.0	0.0	11	0.70	1.7	1.0	26	0.50	1.30	0.0	1.8	3.8
Orange flower	M	850	24375	4300	23	1.0	1075	4.0	14.2	6.5	283	3.4	10.7	14	31	13
	SD	30	1237	220	1.0	0.1	35	0.0	0.35	0.9	34	0.40	0.25	1.0	1.0	0.3
Clover flower	M	11800	35250	5516	56	2.9	4800	5.5	44.7	12.4	500	0.40	15.5	19	51	50
	SD	200	1060	750	5.0	0.14	212	0.7	6.0	0.6	21	0.50	1.4	0.0	7	1.0
Syrup	M	39000	6238	301	1.5	0.50	1775	3.0	1.3	10	285	0.6	1.9	7.5	0.50	9.2
	SD	100	160	65	1.0	0.10	35	0.10	0.28	1.0	20	0.70	0.14	0.70	0.0	0.35

DW, dry weight.
M, mean of ten samples of honey feed (μg/g DW).
SD, standard deviation.

(Bonvehi, 1989). Antonescu and Mateescu (2001) reported that no samples of Rumanian honey contained Cd and As, while it contained Pb 0.0001–0.200 mg/kg, Cu 0.0001–0.500 mg/kg, Zn 0.01–6.2 mg/kg and Fe 0.0001–10 mg/kg in the range within the limits imposed by the last regulations of the Codex Alimentarius (1993).

Comparing the element concentrations in all types of honeys under study (Table 1), syrup -feed honey exhibited higher concentrations of the elements Cd, Co, Cl, Fe, K, Mg, Mn, Pb and Na, (0.5, 3.2, 2680, 3690, 15,550, 1325, 5.7, 9.3 and 2550 μg/g DW, respectively) than in the other types of honey. The presence of these elements (Cd, Co, Cl, Fe, K, Mg, Mn, Pb and Na) in syrup-feed honey in high concentrations was due to the presence of these elements in the soluble inorganic salts which lead to high concentration by bees from syrup to honey. By comparing the element concentration in syrup and the other flowers (sesame, clover and orange) (Table 2), it was found that syrup contains higher concentration of Cl than flowers. Syrup contained a high sugar content (Hamza et al., 1993), and some reported that the presence of K, Zn, Fe and Co in the honey is due to the high sugar content in this honey (Sevimli and Bayulgen, 1992). Syrup-feed honey seems to be a good source of most trace elements. The presence of Cd, Fe and Pb in syrup (Table 2) may be a result of contamination from the industrial process in which corrosion effect the juice by the addition of [$Ca(OH)_2$, $Ca_3(PO_4)_2$, SO_2] in containers during the sugar product processes (Mohamed, 1999). Lead content in Malaysian honey (Mada lebal) was found to be 0.91 ppm lower than in our study (Shahid and Sion, 1987).

The result of element concentrations in the other honey types (sesame honey, clover honey and orange honey) (Table 1) revealed that those honeys contained different element concentrations that depended highly on the type of flowers (sesame, clover and orange) utilized by the bee. Clover honey contained higher levels of Cu, Ni, Sr and Zn (1.75, 4.1, 3.2 and 9.3 μg/g DW, respectively) than in the other honeys. Clover honey can be used to provide human beings with Cu, Ni, Sr and Zn. Orange honey contained higher level of iodine (0.87 μg/g DW) than in the other honeys. Sesame honey contained the highest level of Cd and F (0.50 and 202 μg/g, respectively). Many workers studied the effect of floral type in element contents of the honey. El-Sherbiny and Rizk (1979) stated that cotton honey contained higher element concentration than clover honey. Element concentrations in Spanish commercial honeys were determined, in which the mean values recorded for Na 98, K 653, Ca 88, Mg 38, Cu 0.62, Fe 5.3 and Mn 1.92 mg/kg (Rodrigues-Otero and Paseiro, 1992). Detailed studies were carried out on the mineral composition of some honeys: 15% in orange (Citrus sp.), 20% in rosemary (*Rosemarinus officinalis* l.), 13% in lavender (*Lavandula latifolia* Med.) and 0.77% in forest (*Quercus* sp.) honeys (Bonvehi et al., 1987).

The difference in honey composition was the result of the difference in the flower elemental composition. In all types of honey and bee feeds under study, the studied element concentrations in the bee feed (syrup, clover flower, sesame flower and orange flower) were higher than those in the corresponding honey. Clover flower (Table 2) exhibited higher levels of Cd, Cu, F, K, Na, Pb, Sr and Zn (2.9, 44.7, 12.4, 35,250, 4800, 19, 51 and 50 μg/g DW, respectively) than in the other syrup and flowers. Sesame flower exhibited the highest level of Co, Fe Mg Mn Ni, and Ni, (9.5, 3.85, 4660, 789, 113 and 18.5 μg/g DW, respectively) while orange flower exhibited the lowest levels of elements (Table 2). Sesame flower exhibited higher concentrations of all elements than sesame honey except for fluoride, which was higher in the honey (F, 12.5 μg/g DW in honey, 5.0 μg/g DW in sesame flower). Chloride and iodide were the only two elements present in clover flower in lower levels than in clover honey. Long (1968) reports that the order of element concentrations in honey is in the order K > Mg > Na.

Honey from different sources and locations has been analyzed by many researchers in which clover honey from Egypt exhibited the mean concentrations of elements as follows: K 328, Na 19.52, Ca 42.1, Mg 33.12, Fe 2.9, Cu 0.34 and Mn 0.32 ppm, and these level of elements were lower than those from our study. Cotton honey contained K 1038, Na 88, Ca 124, Mg 78, Fe 8.99, Cu 0.98 and Mn 1.38 ppm (El-Sherbiny and Rizk, 1979). Hamza et al. (1993) studied the elements composition in different types of honey from Saudi Arabia in which honey of the sugar-feed type contained high concentration of Ca (127.7 ppm), while Kateefash honey contained high levels of Fe and K. Sidir honey type contained high concentrations of Na and K. Honey from southeastern Anatolia (Turkey) exhibited Na and K in high concentrations (118 and 296 mg/kg, respectively) while the order of trace elements present were Ca > Mg > Fe > Zn > Cu > Mn > Zn (51, 33, 6.6, 2.7, 1.8, 1, 1 ppm, respectively) (Yilmaz, 1999). Mineral elements in US honey were determined in two types, light honey and dark honey, in which honey composition depended on the plants type used by bees. Crane (1977) shows that dark honey exhibited twice as much element concentrations than light honey (K, 205, 1676 ppm; Cl 52, 113 ppm; Na 18, 76 ppm; Mg 19, 35 ppm; Fe 2.4, 9.4 ppm; Mn 0.3, 4.1 ppm and Cu 0.3, 0.6 ppm (for light and dark honey, respectively). Crane (1975) published the limits of nutrients in honey, in which Ca was 0.004–0.03 g/100 g, Cl 0.002–0.02 g/100 g, Cu 0.01–0.1 g/100 g, Na 0.0006–0.04 g/100 g, K 0.01–0.43 g/100 g, P 0.002–0.06 g/100 g, Cu 0.01–0.1 mg/100 g, Fe 0.1–3.4 mg/100 g, Mg 0.7–13 mg/100 g, Mn 0.2–10 mg/100 g.

Calculated major (Na, K and Mg) and trace elements (Cl, Co, Cr, Cu, F, Fe, I, Mn, Ni, Sr and Zn) intakes from bee honey in Egyptian diet are low because honey is rarely consumed in sufficient quantities and rarely taken with meals. For Mg and Fe, the dietary intake was 3.20–5.77% and 0.07–0.14% of RDA values. The mean intake of Zn, Cu and Mn were below the recommended RDA, their intake were 0.019%, 0.026% and 0.008%, respectively, of the recommended RDA. For toxic metals Pb and Cd, no toxicological problems can be expected from the consumption of honey, with calculated intakes of 0.159% Pb and 0.195% Cd of the present FAO/WHO PTWIs, and below the Minimal Risk Levels (MRLs) (EOS, 1995; WHO, 1982; IPCS, 1992).

3.1. Concentration coefficient

To obtain the rate of element extraction from the bee feed into the honey for this study we applied the following equation:

$$\%\ \text{Element concentration coefficient} = \frac{\text{element concentration in honey} \times 100}{\text{element concentration in the feed}}.$$

By applying this equation on the honeys under study, the concentration coefficient of element in honeys was obtained (Figs. 1 and 2). The results showed that bees concentrated nearly all the studied elements Cd, Co, Cu, Fe, I, K, Mg, Mn, Na, Ni, Pb, Sr and Zn (concentration coefficient 76.9–440%) from syrup to syrup feed- honey in proportions higher than in the other honeys, while lower concentration coefficient was observed for Cl and F. These high element concentration coefficients for syrup feed-honey may be attributed to the high solubility of these elements in the syrup. For the other types of honey, clover honey exhibited the highest concentration coefficients for Cl and F (100% for both) (other elements exhibited concentration coefficients of 0.34–26.4%), while sesame exhibited the highest concentration coefficient for F (90%) only (other elements exhibited concentration coefficients of 1.29–40%). Concentration coefficients for orange honey seem to be low and ranged from 1% to 84%. The high concentration coefficients for Cl and F in clover and F in sesame honey was due to the presence of those elements in highly soluble salts in the nectar of the flower.

The order of concentration coefficient in all the studied honey was as follows: for trace elements Mn > Ni > I > Pb > Co > Cd = Sr > Cu > F, for major elements Fe > Mg > K > Na > Cl.

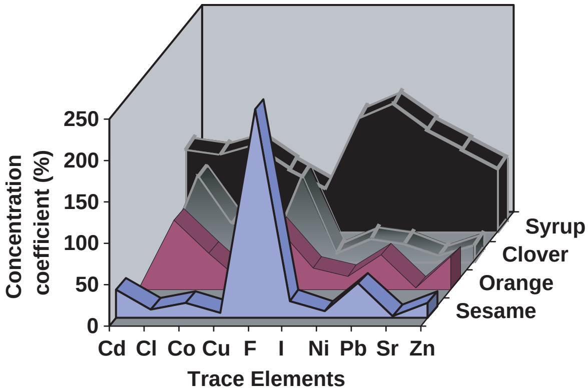

Fig. 1. Concentration coefficient of trace elements in different types of honey.

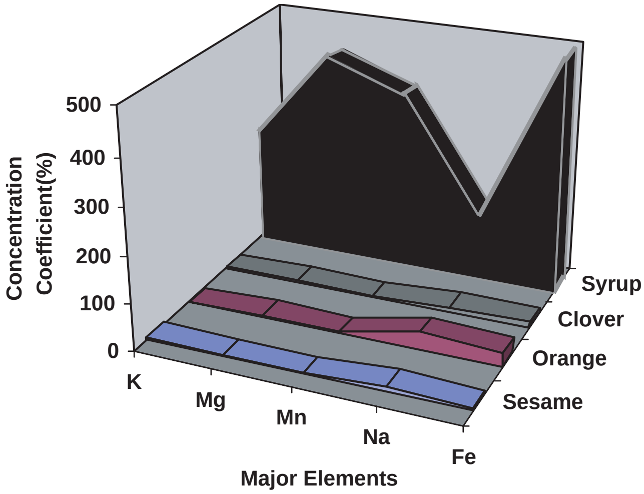

Fig. 2. Concentration coefficient of major elements in different types of honey.

To confirm the presence of the elements in honey in higher concentrations than in bee feed, regression analysis and correlation coefficient analysis between the elements in honeys and the feeds were run (Steel and Torrie, 1980; SAS, 1982). The results of regression analysis (Table 3) showed three classes for the extraction of the elements from the bee feed:

Class I: included those with highest extraction of Cl, Cu, Sr and Zn.
Class II: included those with lowest extraction of F.
Class III: included those with no relationship of these elements in honey from bee-feed and whose presence in the honey could come from other sources (i.e., soil, other plants…etc.)

The correlation coefficient (R) confirmed these results (Table 3).

Table 3
Regression analysis of element concentrations between honeys and bee feeds (flower and syrup)

Class type (element extracted)	Regression equation	R^2	R
Class I	Cl conc = 3367 + 0.937 Cl[a]	0.935	0.967
	Cu conc = −13.2 + 38.7 Cu[a]	0.775	0.880
	Zn conc = −35.4 + 8.97Zn[a]	0.593	0.770
	Sr conc = 13.9 + 11.6Sr[a]	0.569	0.754
Class II	F conc = 7.90 + 0.066F[a]	0.007	0.085
Class III	Cd conc = 1.97–1.94Cd[a]	0.281	−0.97
	Co conc = 11.2–2.49Co[a]	0.369	−0.607
	Mn conc = 67.5–9.1Mn[a]	0.214	−0.463
	Ni conc = 14.9–1.30Ni[a]	0.054	−0.232
	Pb conc = 27.9–2.18Pb[a]	0.942	−0.971
	Fe conc = 1823–0.388Fe[a]	0.104	−0.322
	Mg conc = 7021–5.18Mg[a]	0.857	−0.910
	Na conc = 3186–0.53Na[a]	0.119	−0.346
	K conc = 32568–1.67K[a]	0.829	−0.910
	I conc = 10.4–9.1I[a]	0.119	−0.336

[a] Concentration of element in feed.

3.2. Cluster analysis

Cluster analysis was applied to the data of the 15 elements in the 4 types of honeys under study. The Euclidean distance was used for measuring the similarity and as clustering methods single linkage. The honey samples have been grouped in two clusters. One cluster has only the syrup-feed honey, while the other cluster included the remaining three types of honey (orange, clover and sesame honeys); one group included orange honey and the other linked clover and sesame honeys. These results of cluster analysis revealed that the chemical composition of syrup-feed honey differ from the other types of honeys. Sesame honey and clover honey correlated well with the chemical composition of each other (Fig. 3). Several studies have been done for cluster analysis of chemical data of honeys. Cluster analysis applied to physico-chemical parameters of honey from the Basque country in Spain revealed that the samples have been grouped in 2 clusters; one cluster has only one sample with high diastase activity (Sancho and Munitequi, 1991a). Cluster analysis of data of floral origin and taxons of 115 Basque country (Spain) honeys have been applied using the single linkage. The samples have been grouped in two clusters, one cluster has only the unifloral Lotus sp. honey (Sancho and Munitequi, 1991b).

4. Conclusion

This study shows the chemical composition of major, trace and toxic elements in different types of monofloral honeys (clover honey, sesame honey and orange honey) and artificial feed honey (syrup-feed honey). The artificial feed honey (syrup-feed honey) exhibited higher concentrations

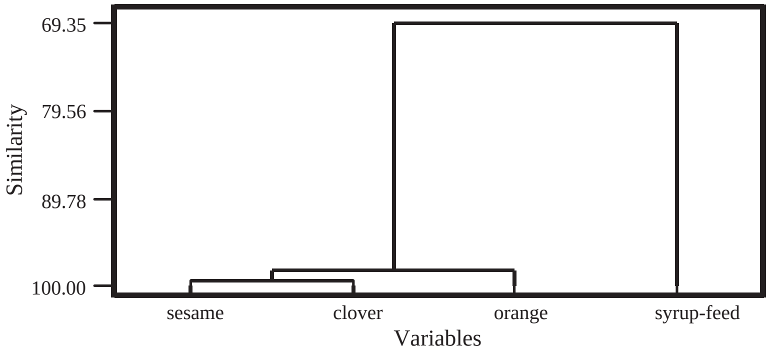

Fig. 3. Dendograme of cluster analysis of elements in different types of honeys.

of the elements Cd, Co, Cl, Fe, K, Mg, Mn, Pb and Na than the other honeys (clover honey, sesame honey and orange honey). The statistical analysis of the data reveals a correlation of specific elements between honey and the bee feed utilized. Cluster analysis of the honeys revealed that the origin of the honey samples was based on its chemical composition. Element concentrations in honey under study were in the safety baseline levels for human consumption.

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